Examining microstructure of industrial brass blanks with purpose for quality control in respect of defects of technological origin

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Abstract. The microstructure of industrial blanks made of brass L63 and L68 was examined for quality control. Exogenous inclusions and pores in the microstructure of blanks were found. The microstructure was examined by means of traditional metallographic analysis methods. The authors investigated the transition from exogenous inclusions and pores, which were not removed at the initial processing stage, to the crack, which leads to billet destruction at one of the last processing stages. A conclusion was made about the need for quality control brass blanks by metallographic method. Without quality control it is impossible to provide guarantee of reliable operation of machines and responsible purpose constructions.

1. Introduction

Brasses L63 and L68 have good strength and corrosion resistance, although their structure and properties are a function of zinc content. Brass L63 contains 35-38% zinc, brass L68 contains 30-33% zinc. Effects of the chemical composition of brasses L63 and L68 and the amount, morphology, and chemical composition of the phases forming these brasses (α-solid solution of alloying elements in copper and β-phase based on electronic compound CuZn) have been studied [1-5]. Brass L63 contains a small amount of β-phase. α-copper is the primary phase in cast alloys containing up to 40% zinc. β - phase, which is the high zinc phase, is the minor constituent filling in the areas between dendrites of α-phase . The microstructure of brasses containing up to 40% zinc consists of dendrites of α-phase and β-phase surrounding the dendrites. Cast alloys with greater than 40% of zinc contain primary dendrites of the β-phase. If the material is fast-cooled, the structure consists entirely of β-phase. During a slower cool, α - precipitates out of the solution at the crystal boundaries, forming a structure of β-phase dendrites surrounded by α-phase. Brass L68 is a single phase alloy, consisting of a solid solution of zinc in α-copper. Brass L68 is characterized by high strength and ductility, so brass L68 processed by pressure without heating. Brass L68 is characterized by higher strength and ductility, so brass L68 is processed by pressure without heating. The strength and ductility of Cu-Zn alloys becomes bigger with increasing zinc content. Increasing the zinc content up to 35 % produces a stronger, more elastic alloy with a moderate decrease in corrosion resistance. Brasses containing between 32 and 39% zinc have a two phase structure, composed of α and β phases.

The metallographic inspection of industrial brass blanks is aimed at the identification of defects in a metal, including internal discontinuity flaws. The metallographic inspection of brass blanks made of L63 and L68 brass at the JSC "Revda Non-Ferrous Metals Processing Works" has found zones of discontinuity flaws, in places, where exogenous inclusions and pores were located. This is a contestable fact for drawing a conclusion on compliance of industrial brass blanks quality with the requirements of GOST 32597-2013. GOST 32597-2013 establishes the types of defects only in the surface of ingots, rolled and extruded billets, semi-finished and finished products of copper, nickel and their alloys. This standard does not specify the technical requirements for product quality, but defines types of defects. The defects listed in this standard are not definitive signs of rejection. The eddy-current method is most often used for definition of brass defects [6]. The pros and cons of this method were determined, and according to them, the appropriate conclusions were made. Alternative methods of defects control are also ultrasonic methods, used for definition of surface and deep defects, cracks, sinks and separations in metallic and non-metallic materials [7]. Metallographic methods of controlling brass defects are usually applied for detection of gross defects: cracks, sinks and segregations of atoms [8-10]. Metallographic methods are utilised for definition of the defects of metallurgical origin: nonmetallic inclusion, pores and discontinuity flaws.

2. Materials and methods

Samples of brasses L63 and L68 taken from ingots, tubes, rod, billets for pressing were used as the study object. The samples were selected at JSC "Revda Non-Ferrous Metals Processing Works" from zones of industrial blanks brass, where discontinuity flaws, exogenous inclusions and pores were located. The microstructure of samples was studied by traditional methods of quantitative metallography with the use of an optical microscope "Neofot-32". For the preparation of samples, the authors used "Logitech PM5". The microstructure of samples was studied by traditional methods of quantitative metallography, applying an optical microscope "Neofot-32". Metallographic analysis was performed using the hardware-software complex SIAMS700.

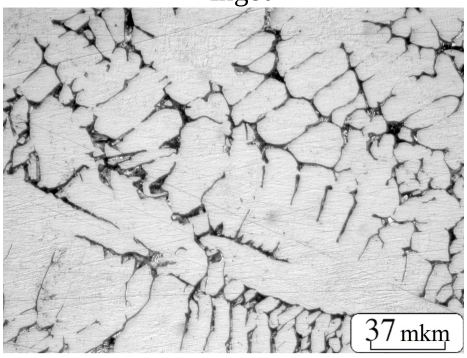
3. Results and Discussions

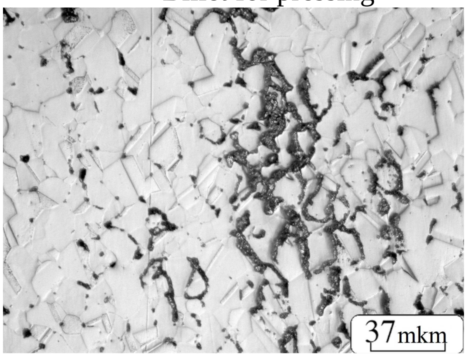
The microstructure of brasses L63 is shown in Fig. 1. According to results of studies [2-3], the authors made assumption on presence of two phases in the microstructure: an α-solid solution of alloying elements in copper; a β-phase based on the electronic compound CuZn. Correlation between characteristics of the microstructure of metal and existence of defects was found. When approaching the crack in the billet for pressing, a two-phase (α + β) microstructure appears. In the microstructure of the ingot and the billet for pressing, particles of exogenous inclusions were also discovered.

The microstructure of brasses L68 is shown in Fig. 2. According to results of studies [2-3], the authors assumed the presence of one phase in the microstructure: an α-solid solution of alloying elements in copper. In the microstructure of metal, the existence of three types of defects was found. These are exogenous nonmetallic inclusions; gas bubbles and discontinuities; liquation inclusions in the microstructure of the alloy. When approaching the crack in the billet for pressing, a two-phase (α + β) microstructure appears. In the microstructure of the ingot and of all the billets, particles of exogenous inclusions were also discovered.

Ingot | Billet for pressing

a





b

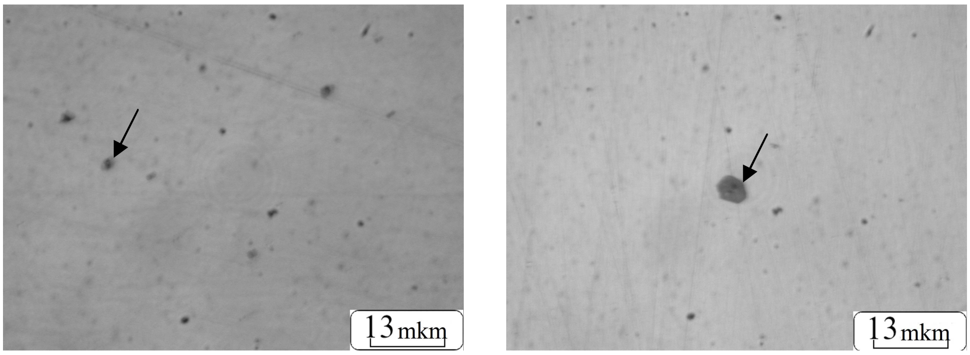


Figure 1. Microstructure of brass L63: white - α-solid solution of alloying elements in copper; bleak - β-phase based on the electronic compound CuZn. In pictures cursor designates particles of exogenous inclusions. a - microstructure of alloy from grains; b - microstructure of alloy with exogenous nonmetallic inclusions

Ingot | Rolling blank | Rolling blank after annealing | Blank after drawing mill | Blank after drawing mill and annealing

a
b
c
d

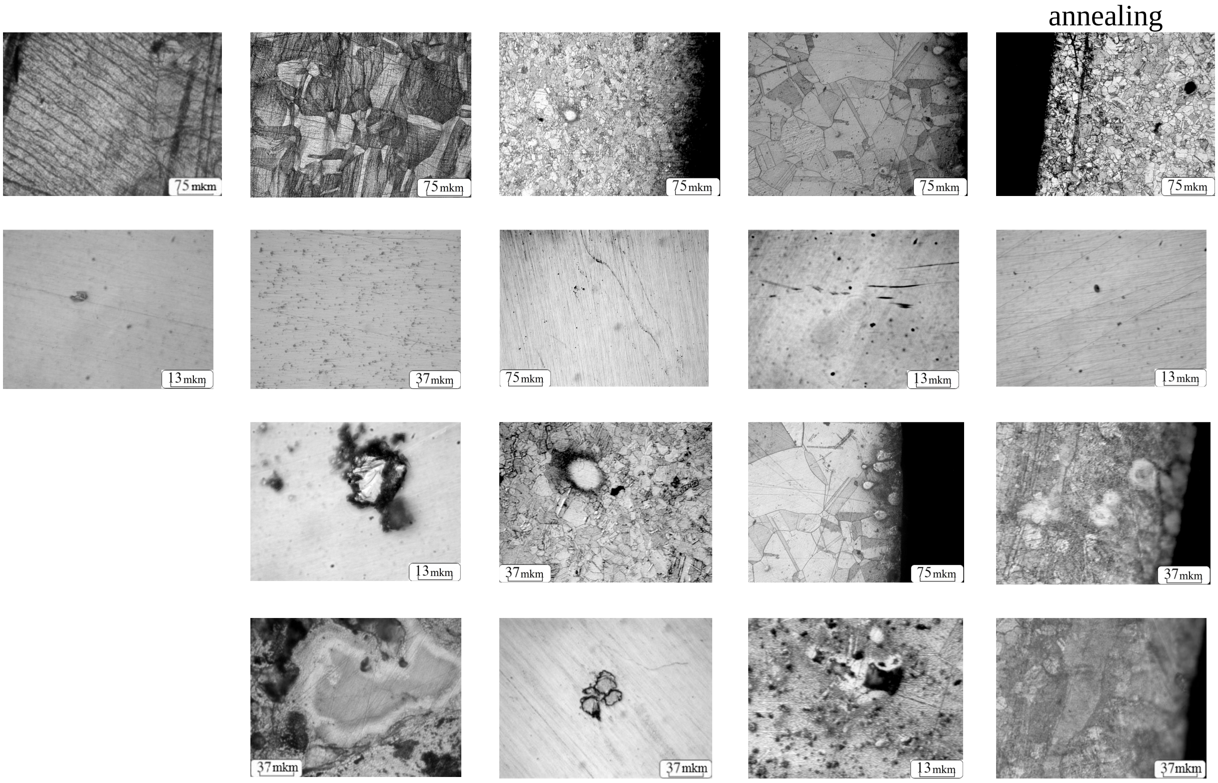


Figure 2. Microstructure of brass L68. a - microstructure of alloy from grains; b - microstructure of alloy with exogenous nonmetallic inclusions; c - gas bubbles and discontinuities in microstructure of alloy; d - liquation inclusions in microstructure of alloy.

Fig. 3 shows the transition from one type of defects in the microstructure (exogenous inclusions, pores, liquation inclusions), which were not removed at the initial processing stage, into another type (the crack), which leads to billet destruction at one of the processing stages. It was found that, usually, casting defects (blowholes, pores and liquation) do not cause cracking, but during the pressure treatment they decrease strength characteristics [10]. A discontinuity in the metal does not allow putting the ingot in hot pressure treatment in order to avoid defective production. Therefore, without the quality control of metals and metal-products by the metallographic method, it is impossible to provide guarantee of reliable operation of machines and responsible purpose constructions.

Nonmetallic inclusion in brasses affects the mechanical properties dramatically adversely and reduces strength and ductility. In places, where inclusions are formed, there are pockets of corrosion. Exogenous inclusions in particulate molding material fall into the melt fracture of the material and are shaped in the crucible by pouring, as well as using brass return melting metal. Metallographic studies showed the complex composition of these inclusions: SiO_2, ZnO, MnO, Al_2O_3. Also non-metallic inclusions are formed during the pouring of the stocking on the metal stream. There is another source of getting non-metallic inclusions in the melt-oxides, which are available on the surface of raw materials.

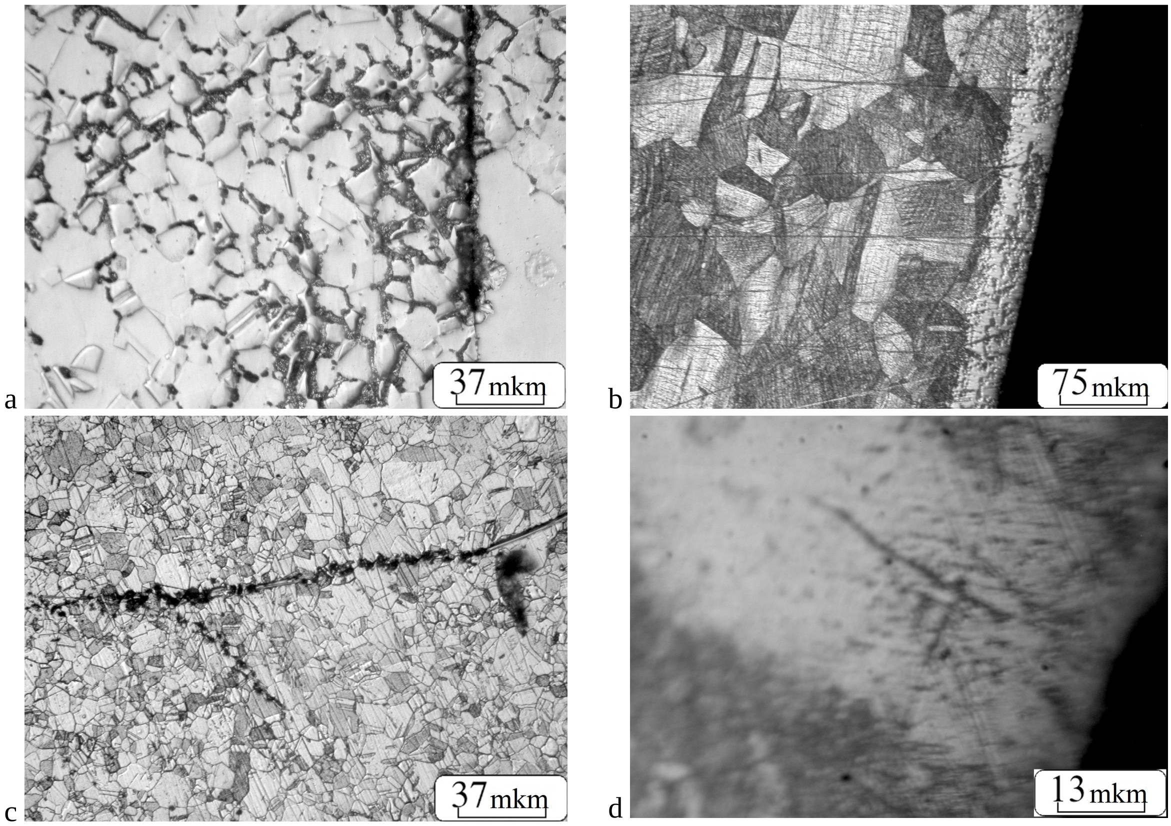


Figure 3. a - press billet of brass L63. Microstructure near crack is two-phase. b - liquation zone on surface of rolled billet from L68 brass; c - blank after drawing mill and annealing from L68 brass; cracking on non-metallic inclusions; d - blank after drawing mill and annealing from L68 brass. Crack in separation zone.

4. Conclusion

The microstructure of ingots and billets for pressing and rolling made of brass L63 and L68 was examined for quality control. Exogenous nonmetallic inclusions, pores, liquation inclusions in the microstructure of brass blanks were found. These defects are described with the assistance of JSC "Revda Non-Ferrous Metals Processing Works". The microstructure was examined by means of traditional metallographic analysis methods. The authors demonstrated the transition from one type of defects (exogenous inclusions, liquation inclusions and pores), which were not removed at the initial processing stage, into another type (crack), which leads to billet destruction at one of the last processing stages. Therefore, without the quality control of metals and metal-products by the metallographic method, it is impossible to provide guarantee of reliable operation of machines and responsible purpose constructions.

References

[1] Kundig K J A and Cowie J G 2006 *Copper and Copper Alloys* (Mechanical Engineers' Handbook: Materials and Mechanical Design) pp 117-220

[2] 2004 *Copper Development Association Inc. and ASTM International ASTM Standard Designations for Wrought and Cast Copper and Copper Alloys* (New York)

[3] Momeni A, Ebrahimi G R, Faridi H R 2015 Effect of chemical composition and processing variables on the hot flow behavior of leaded brass alloys *Materials Science and Engineering A*. **626** 1-8

[4] Pugacheva N B, Pankratov A A, Frolova N Yu, Kotlyarov I V 2006 Structural and phase transformations in α + β brasses *Russian Metallurgy (Metally)* **3** 239-248

[5] Hameed A H, Abed A T 2014 Effect of secondary cooling configuration on microstructure of cast in semi-continuous casting of copper and brass *Applied Mechanics and Materials* **575** 8-12

[6] Pugacheva N B, Ovchinnikov A S, Lebed A V 2014 Analysis of defects of industrial brass blanks *Tsvetnye Metally* **10** 71-77

[7] Muikku A, Hartikainen J, Vapalahti S, Tiainen T 2006 Experimental work on possibilities to predict casting defects in LPDC brass castings *Materials Science Forum* **508** 561-566

[8] Garagnani G L, Piasentini F, Cesa G V P 2006 Microstructural and mechanical characterization of foundry copper alloys for artistic applications *Metallurgia Italiana* **98** 39-46

[9] Fatemi A, Morovvati M R, Biglari F R 2013 The effect of tube material, microstructure, and heat treatment on process responses of tube hydroforming without axial force *International Journal of Advanced Manufacturing Technology* **68** 263-276

[10] Nagata S, Kai H, Enokizono M 2011 Non-destructive evaluation for internal defect of metal casting *Materials Science Forum* **670** 151-157